
Winter ecology & survival of Cerulean Warblers in coffee plantations in Venezuela
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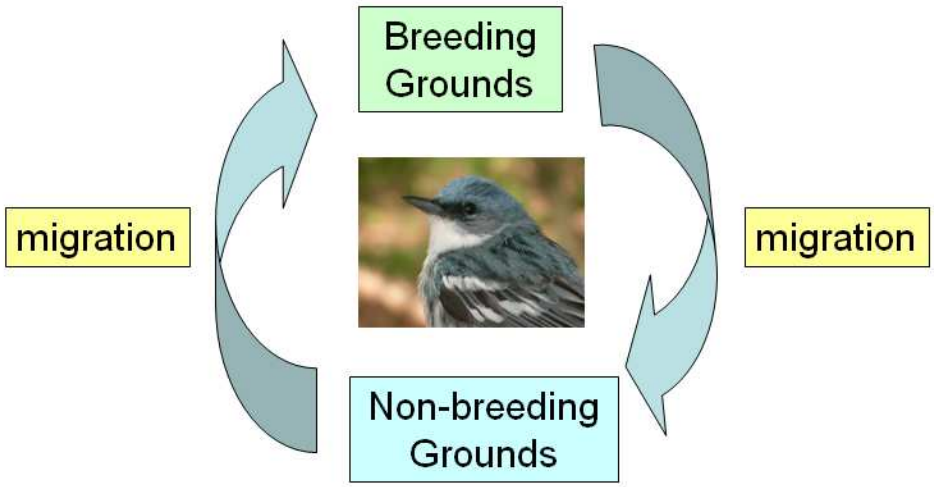
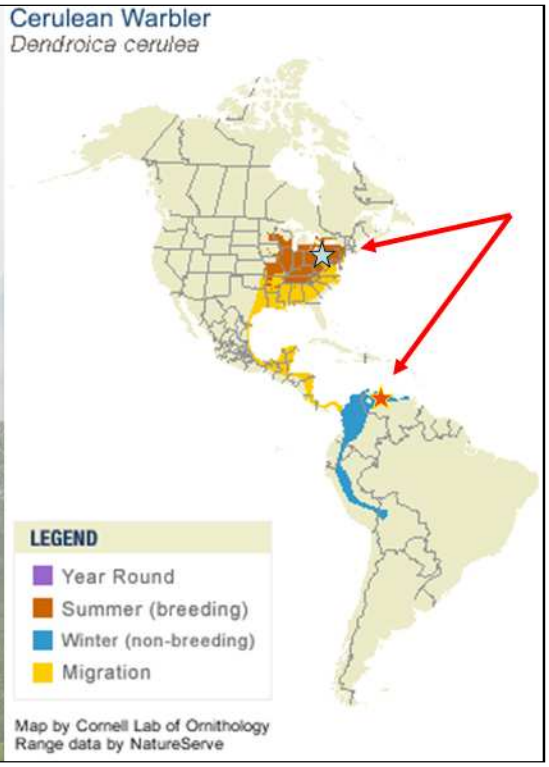
Photo: M. Bakermans

One challenge to conservation:
We don't know where populations are limited.



We are addressing potential causes of decline due to:

- Nonbreeding ground events in Andes
- Breeding ground events in se Ohio

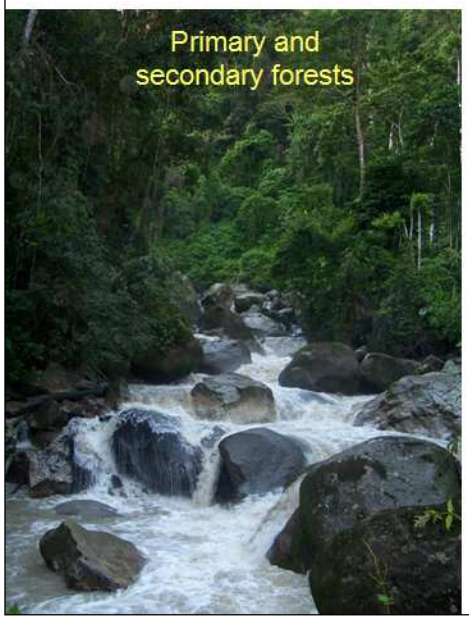


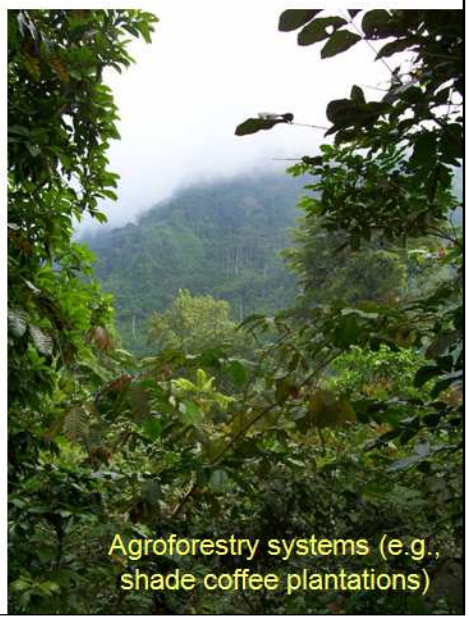
Study winter ecology in Venezuela

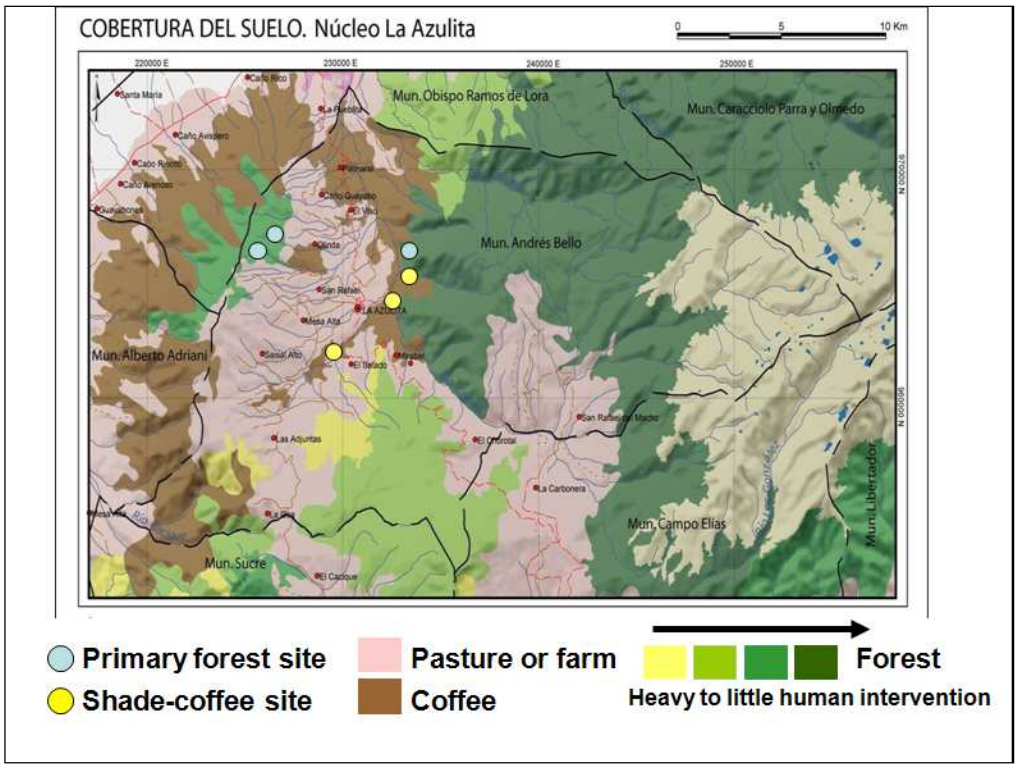
Marja Bakermans, Ph.D.

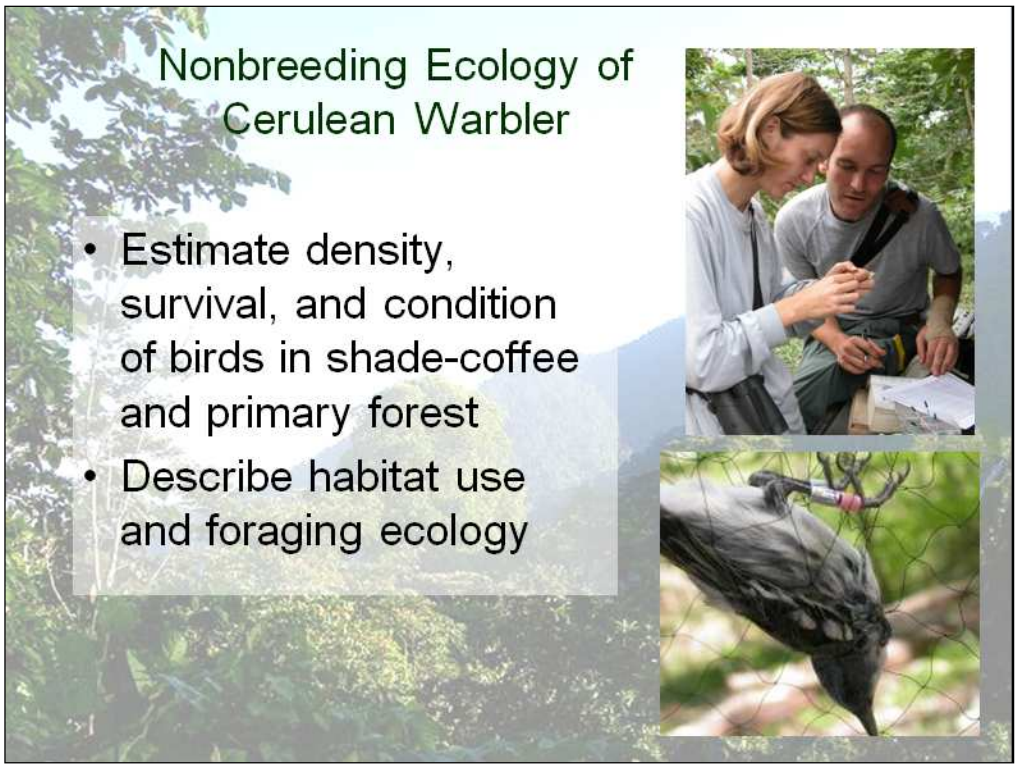
La Azulita

Winter Ecology

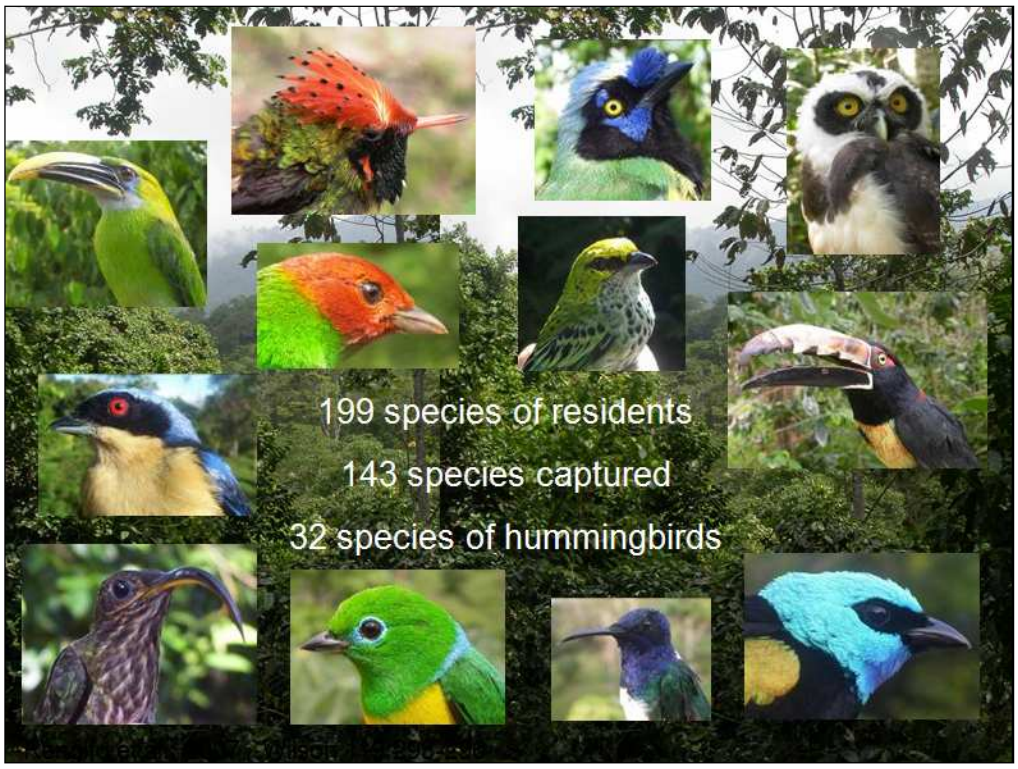





COBERTURA DEL SUELO. Núcleo La Azulita
0
5
10 Km
220000 E
230000 E
240000 E
250000 E
Mun. Obispo Ramos de Lora
Mun. Caracciolo Parra y Olmedo
Mun. Andrés Bello
Mun. Alberto Adriani
Mun. Sucre
Mun. Campo Elías
Mun. Libertador
La Azulita
Primary forest site
Shade-coffee site
Pasture or farm
Coffee
Forest
Heavy to little human intervention



Wintering grounds research occurred on the western slopes of the Venezuelan Andes from December 9, 2005- February 9, 2006 and November 27 2006 through February 7, 2007. Over two years, 119 distance-based line transects were conducted in both shade-coffee plantations and primary forest sites to estimate Cerulean Warbler (*Dendroica cerulea*) densities in each habitat type (10 routes in each habitat type). Using passive mist-netting in both shade coffee plantations and forest sites we captured and banded 274 Neotropical migrants of 14 species. In 2006-07 we recaptured 19 individuals of 9 species from the first season (2005-2006). In 2005-06, we banded 20 individual Cerulean Warblers. In 2006-07, we captured 16 individuals, which includes 7 individuals from the first season. In addition, of the 20 individual Cerulean Warblers color-banded during the first season, 12 of these individuals were resighted throughout the second season. Composition of migrant species in mixed species flocks were documented in both shade coffee (n = 128) and primary forest (n = 37). Foraging observations were taken on male (2005-06: n = 132; 2006-07: n = 53) and female (2005-06: 156; n = 2006-07: n = 81) Cerulean Warblers throughout the wintering season. In addition, habitat characteristics were measured in 0.04-ha circular plots located along each line transect (n = 20).



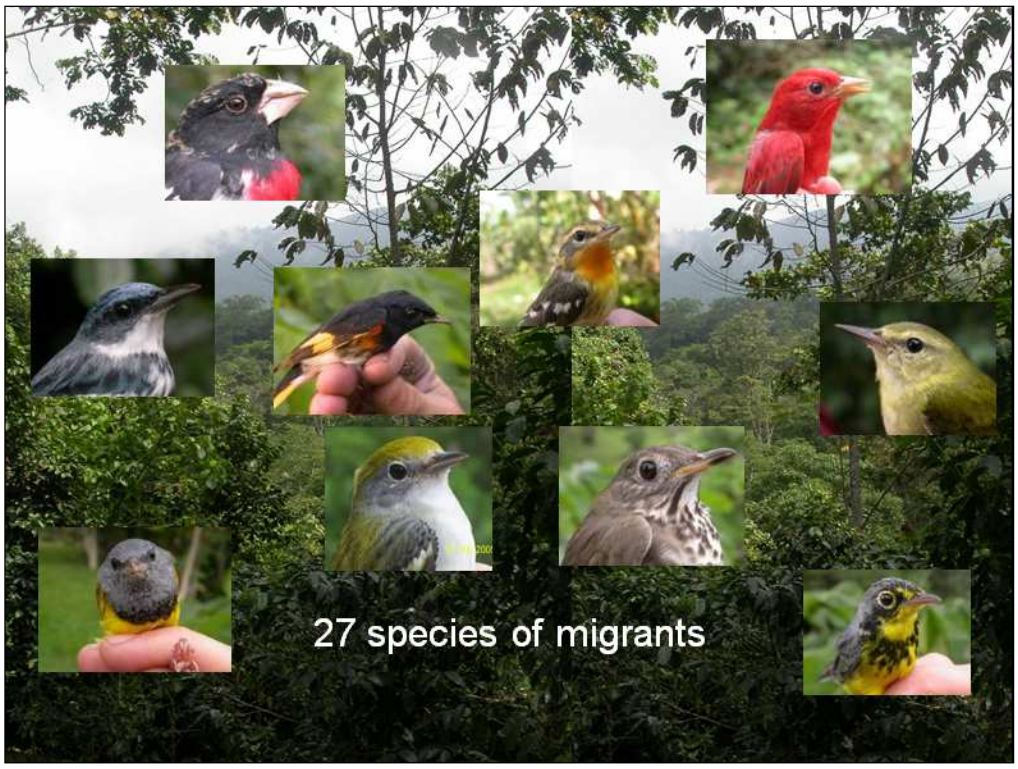
We also documented almost 200 species of residents in the region. We captured 143 of these in shade coffee plantations.

We also had a new record for the White-tipped sicklebill pictured in the bottom left. This genus had never been documented in Venezuela before.(Eutoxeres aquila)

The white-tipped sicklebill is a resident of central America from Costa Rica to Panama and of S. America on the pacific slope of Colombia and Ecuador and on the eastern slope of the Andes from Colombia to Peru.

This is often a hidden bonus when working in the tropics – we never saw the bird foraging in the area, but were thrilled when we captured it in one of our mist nets.

Know: total # of bird species in Venezuela

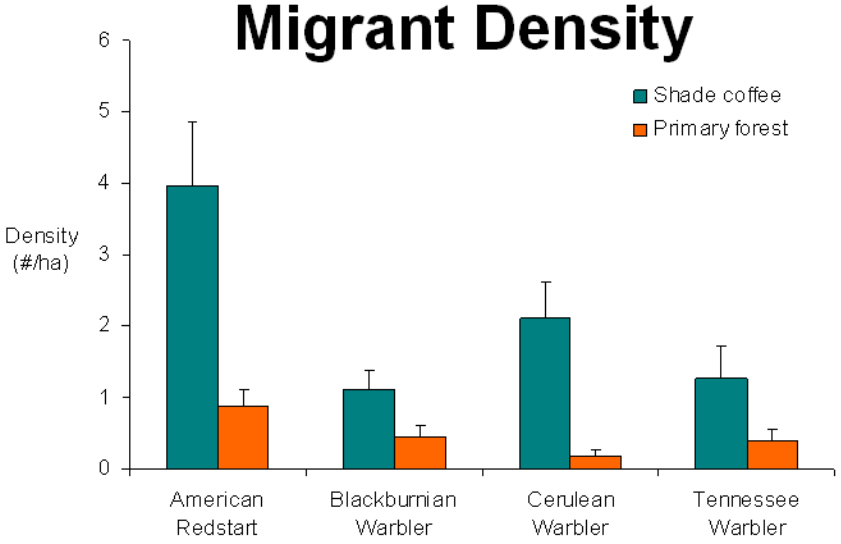


We documented 27 species of NTMBs in the Venezuelan Andes and had two new records for migrants in the region including CSWA and MAWA.

On Colombia project –on eastern cordillera required 300 net hours to capture 1 CERW (and in general, 555 net hours)

Capture rates decreased over the years – possibly due to conversion of surrounding landscape. Captured 12 birds (11 new, 1 recapture; 7 female, 5 male; 9 adult, 2 juv) in 2006-2007. (we caught 9 new plus 7 recaps = 16 total).

Migrant Density



Based on 10 transects per habitat surveyed 7x/year for 2 years for 280 visits; analyzed with DISTANCE

$F_{4,15} = 6.53$, $P = 0.003$

Density (Prelim. Data)

HABITAT	LOCALITY	INDIV/HA
Shade coffee plantation	VENEZUELA	2.5
	COLOMBIA	0.8
Secondary forest & borders	COLOMBIA	0.7
Mature forest	VENEZUELA	0.6
	COLOMBIA	< 0.4
Sun coffee	COLOMBIA	0.0

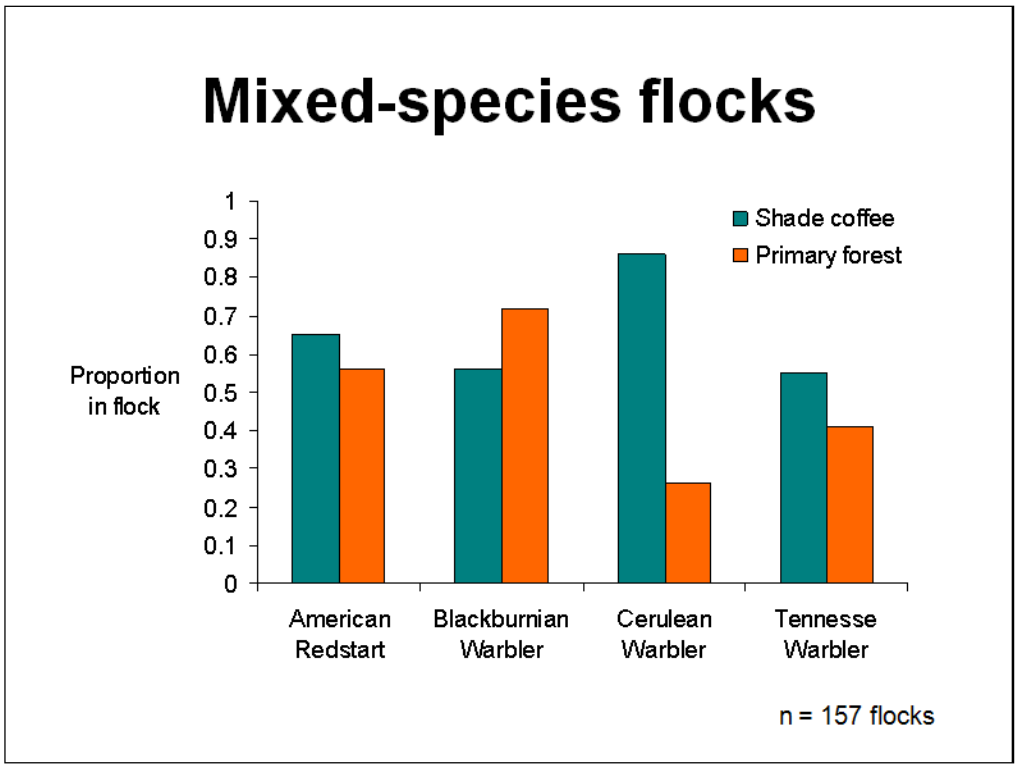
Distribution of CERWs may respond not only to habitat type, but also to other factors such as availability of habitat

Colombia data from Gabriel Colorado

Compared to the Colombian study, our densities of Cerulean Warbler were similar in forest

But greater in shade coffee (2.5 in Venezuela versus 0.8 in Colombia)

Currently, it is unclear why this differences exits. It is possible that the sites in Colombia were more isolated or had different floristic structure.



We collected species information from mixed-species flocks encountered in both primary forest and shade coffee plantations.

You can see from the graph that the most common migrant found in these flocks in primary forest was Blackburnian Warbler, found in 72% of flocks (Table 7).

Cerulean Warblers were the most common migrant detected in flocks in shade coffee plantations (Table 7).

Flocks in primary forests seldom contained Cerulean Warblers (86% versus 26%).

Ceruleans are 2nd most abundant migrant within flocks

Species	Code	Abundance	Foraging Guild
American Redstart, *Setophaga ruticilla*	AMRE	0.70 ± 0.14	Lower canopy
Cerulean Warbler, *Dendroica cerulea*	**CERW**	**0.46 ± 0.11**	**Upper canopy**
Tennessee Warbler, *Vermivora peregrina*	TEWA	0.31 ± 0.11	Upper canopy
Blackburnian Warbler, *D. fusca*	BLBW	0.31 ± 0.07	Upper canopy
Northern Waterthrush, *Seiurus noveboracensis*	NOWA	0.07 ± 0.03	Ground
Black-and-white Warbler, *Mniotilta varia*	BAWW	0.06 ± 0.03	Bark gleaner
Mourning Warbler, *Oporornis philadelphia*	MOWA	0.06 ± 0.03	Ground
Summer Tanager, *Piranga rubra*	SUTA	0.04 ± 0.02	Upper canopy
Acadian Flycatcher, *Empidonax virescens*	ACFL	0.03 ± 0.02	Air /low canopy
Chestnut-sided Warbler, *D. pensylvanica*	CSWA	0.03 ± 0.03	Lower canopy
Bay-breasted Warbler, *D. castanea*	BBWA	0.01 ± 0.01	Upper canopy
Canada Warbler, *Wilsonia canadensis*	CAWA	0.01 ± 0.01	Ground/low canopy
Black-throated Green Warbler, *D. virens*	BTGN	0.01 ± 0.01	Upper canopy
Gray-cheeked Thrush, *Catharus minimus*	GCTH	0.01 ± 0.01	Ground/low canopy
Rose-breasted Grosbeak, *Pheucticus ludovicianus*	RBGR	0.01 ± 0.01	Upper canopy
Swainson's Thrush, *C. ustulatus*	SWTH	0.01 ± 0.01	Ground/low canopy
Yellow-throated Vireo, *Vireo flavifrons*	YTVI	0.01 ± 0.01	Canopy

Mixed-species flocks

Clear mixed-species flocking behavior (86% in Venezuela, 82% in Colombia)

Large #s of CERWs in flocks (1-9 in Venezuela, 1-8 in Colombia)

More common than previously reported (often >1 pair)

More than 70 bird species recorded in mixed-species flocks

G. Colorado

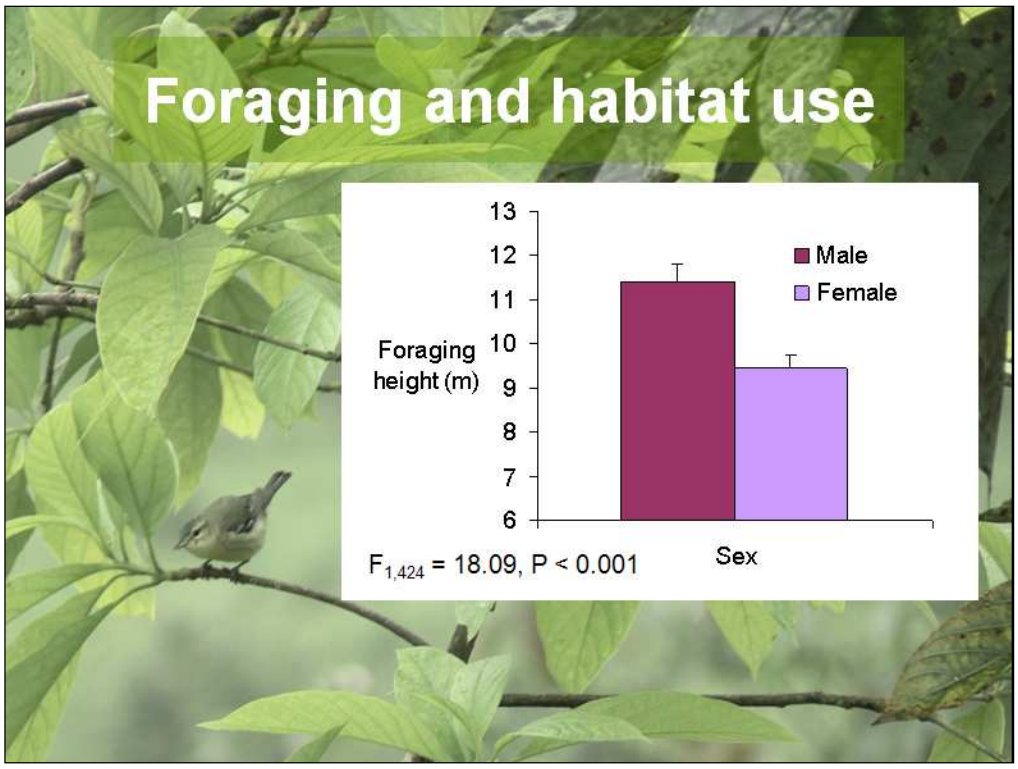
Flocking behavior for CERWs seemed important in shade coffee plantations in Venezuela as well as Colombia.

Eighty-six percent of these flocks contained Cerulean Warblers in Venezuela and 82% in Colombia.

Interestingly, we found some flocks containing large #s of Ceruleans with a range up to 9 Ceruleans for Venezuela and up to 8 in Colombia.

This is more than what has been observed in the past when it was suggested that up to 1 pair (1 male with 1 female) would occupy a flock.

OF course, mixed species flocks contain a wide variety of migrant and resident birds and may move large distances.



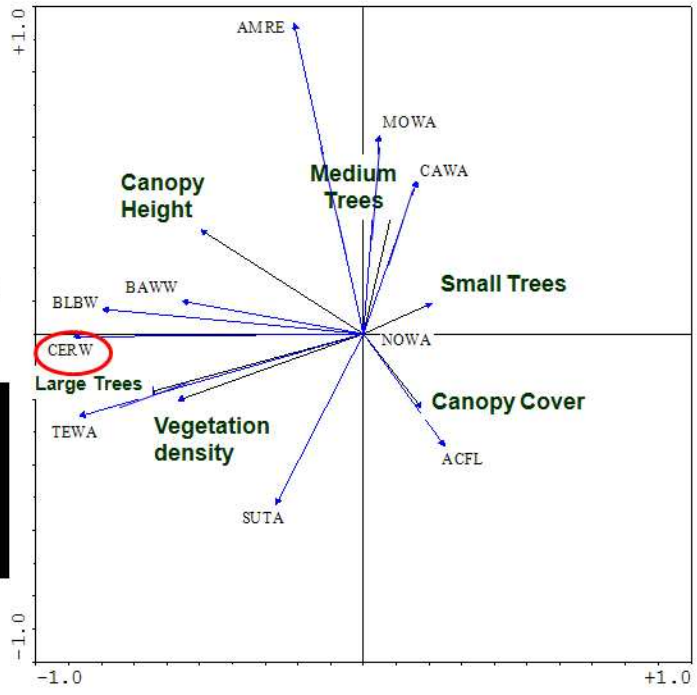
In addition to demographic measures within shade coffee, we examined habitat use of Cerulean Warblers.

As you can see by this slide, males foraged significantly higher than (11.4 m ± 0.4 SE, range = 0.5 – 29.0m) females (9.4 m ± 0.3 SE, range = 1.0 – 31.0m).

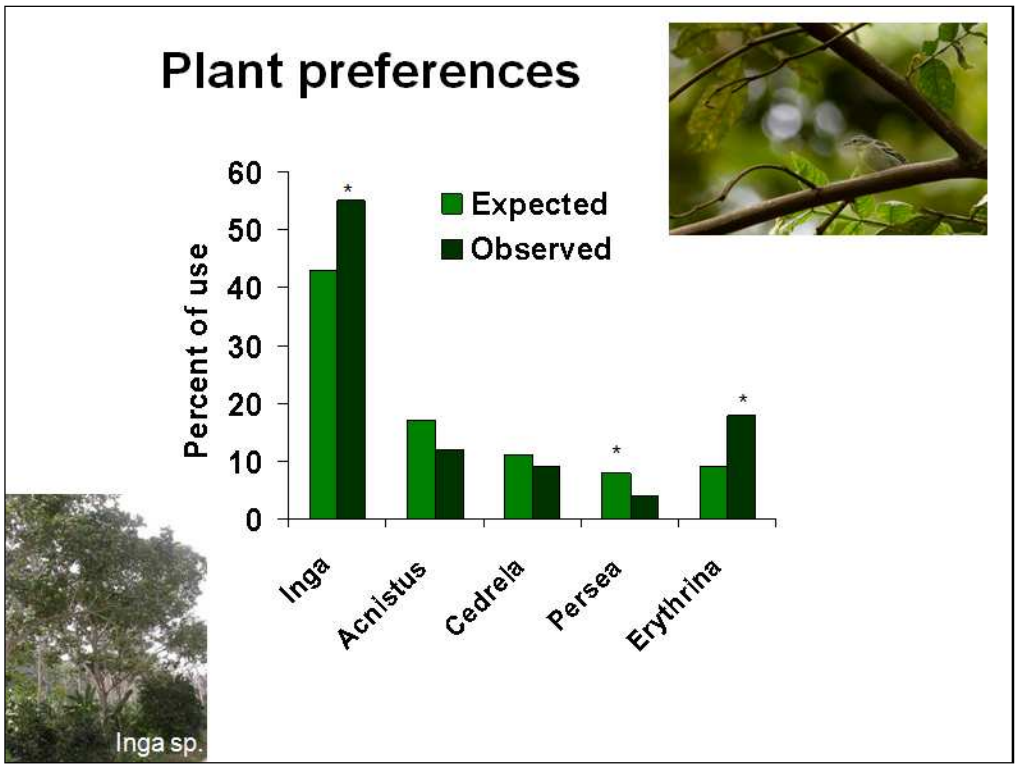
The most common foraging maneuver was glean (88.0%) directed at foliage (91.5%).

Ceruleans most often foraged in the outer branches of each substrate. A good example is this female in the slide. She was in the process of hoping to the outside of this avocado branch in search of insects on the leaves when I took this photo.

Structure of shade coffee



Tree species associations



Next,we looked at whether ceruleans were selecting certain tree species. Here you can see that Inga trees were both available and used in the highest proportion.

Overall, there was no difference in the substrate used in foraging versus those available throughout shade coffee plantations.

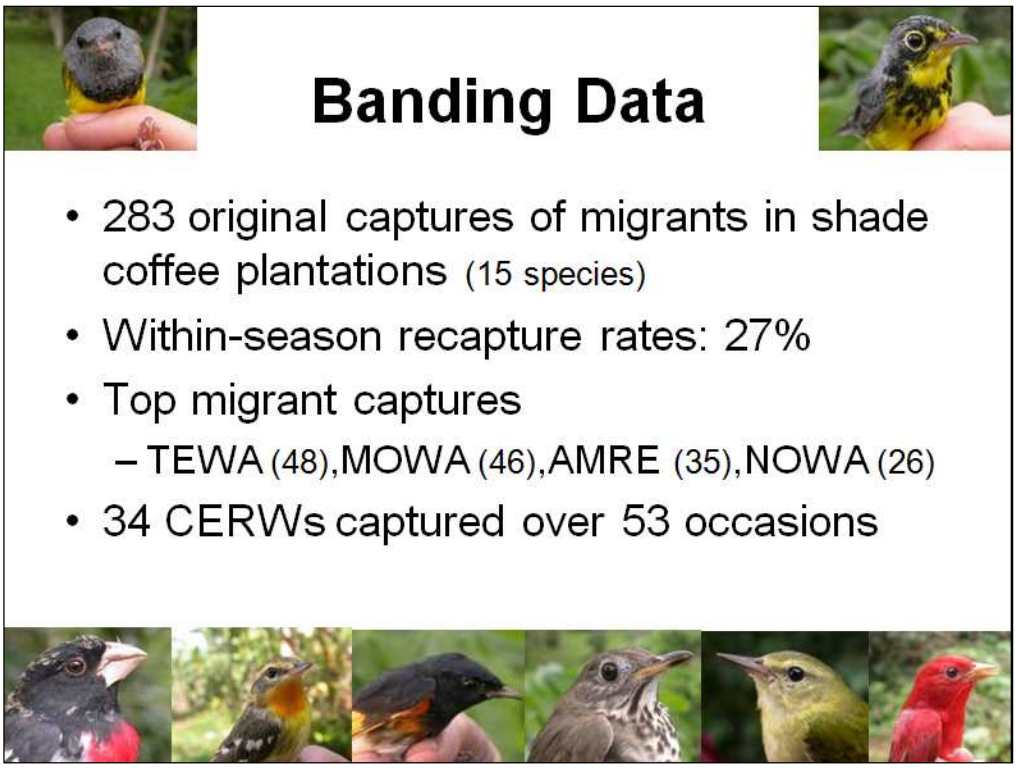
Again, shade coffee plantations dominated by *Inga* spp. have been shown to provide large numbers of arthropod (Johnson 2000, Johnson and Sherry 2001) and nectar resources (Greenberg et al 1997).

In our study, foraging attempts by Cerulean Warblers were most frequently directed at *Inga* spp. trees.

At the same time, though, our data fail to show that *Inga* trees were used out of proportion of their availability.

This does not necessarily indicate that Ceruleans show no selection for *Inga* because they may select plantations, as a whole, based on tree species composition.

Additional work across sites with a wide range of *Inga* abundance is needed to properly evaluate the effects of floristics on habitat use by Cerulean Warblers.



Due to the low capture rates in primary forest, we decided to concentrate mist-netting in shade coffee plantations. So any banding data that I present will ONLY be for shade coffee plantations.

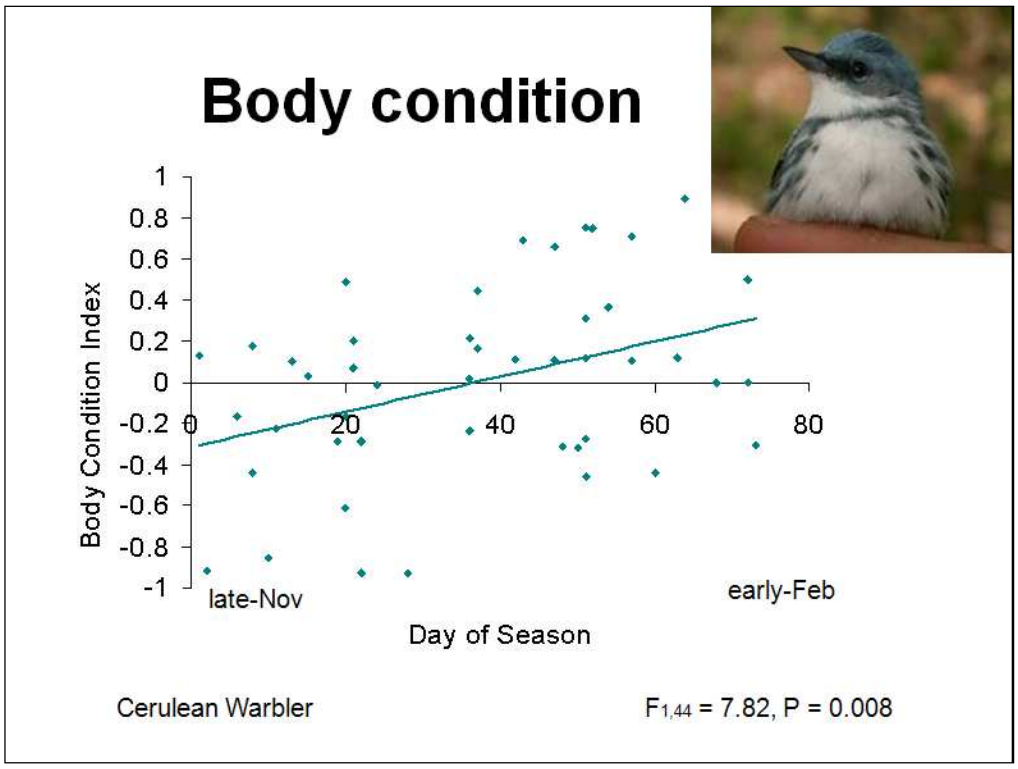
We had 283 original captures of 15 different species.

Again, with a recapture rate of 27% within the same season, we suggest these birds are remaining in the study sites throughout the winter.

Our top migrants captured include TEWA, MOWA, AMRE, AND NOWA with the # of individuals captured in parentheses.

And of course, we were very happy to capture 29 individual CERWs over 47 occasions.

Our capture rates of migrant birds per 100 net hours in shade coffee plantations was comparable to those from studies in Costa Rica, Dominican Republic, and Puerto Rico (see Komar 2006).



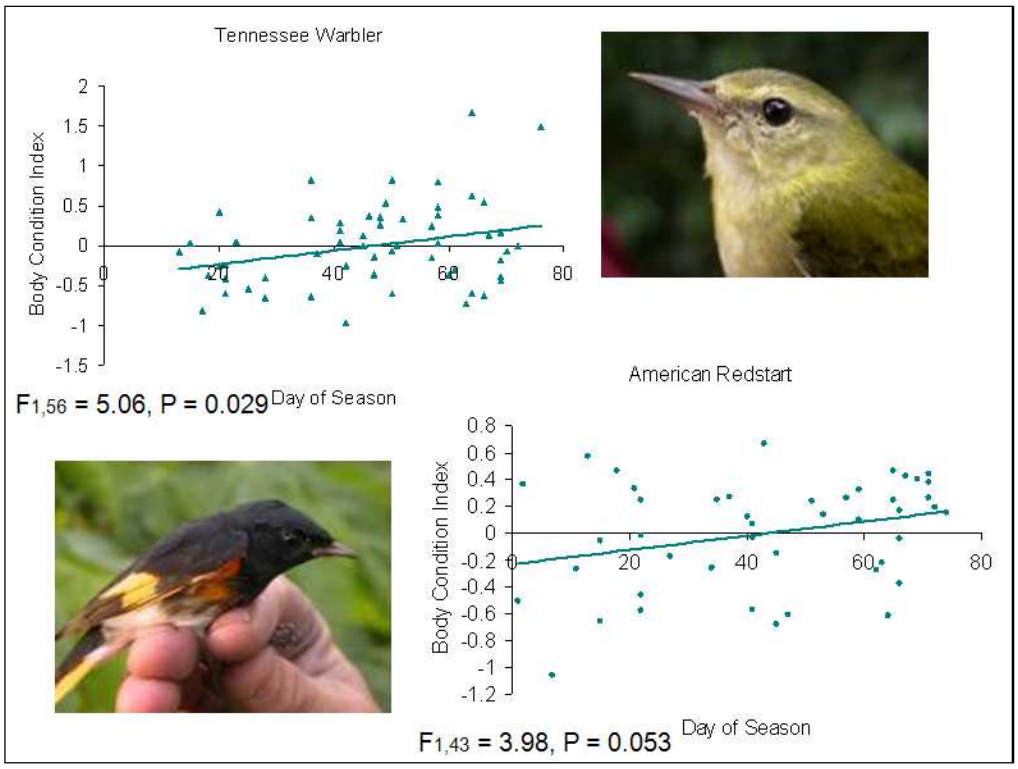
Looking more closely at our banding data, you can see here that our size-adjusted body condition increased for CERWs as the banding season progressed.

Any birds falling below the horizontal 0 line (on the x-axis) are in 'below average' condition, while birds above the 0 line are above average in condition.

We calculated a body condition with PCA that adjusted for structural size of each bird. We then investigated if body condition changed over the course of the banding season.

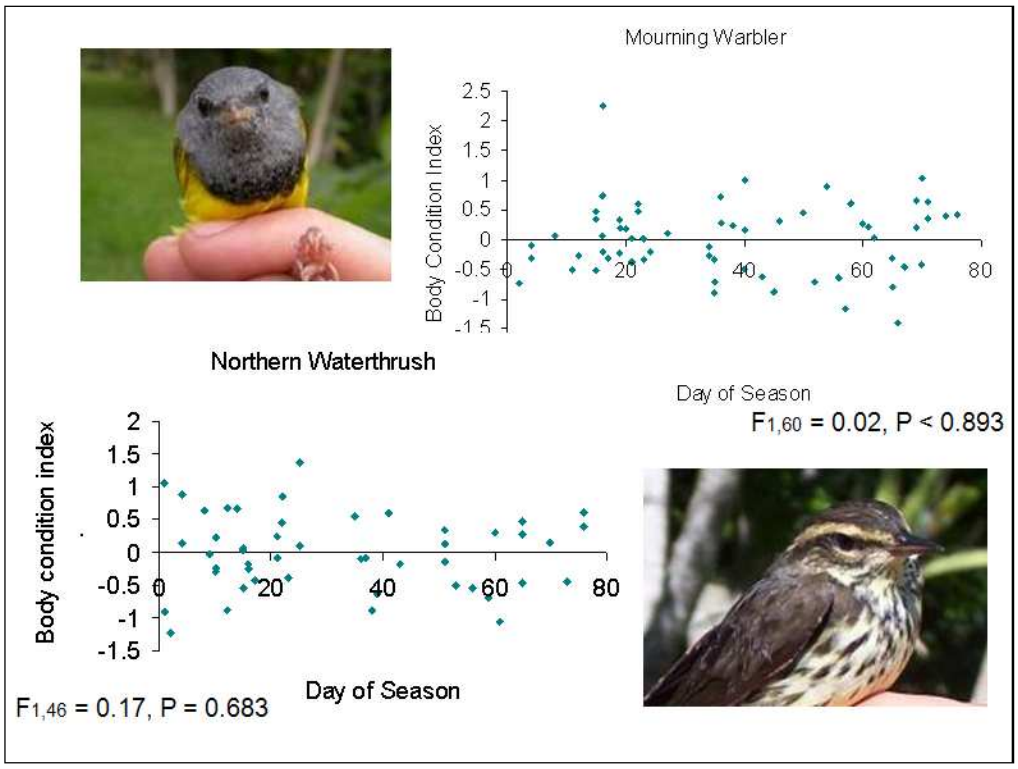
Body condition increased as the day of the season progressed for Cerulean Warbler ($F_{1,44} = 7.82$, $P = 0.008$), Tennessee Warbler ($F_{1,56} = 5.06$, $P = 0.029$), and American Redstart ($F_{1,43} = 3.98$, $P = 0.053$; Figure 2).

Our body condition metric accounted for body frame (structural) size by first performing a principal components analysis (PCA) on morphometric variables (wing chord and tarsus length). Body size was regressed against mass and the residuals were used as a condition index. The extent to which the predicted values deviated from expected mass given a certain body size (i.e., residuals) indicated whether the bird was in good (i.e., residual above the regression line) or poor (i.e., residual below) body condition (Strong and Sherry 2001, Wunderle and Latta 2000).



Both TEWAs and AMREs exhibited the same pattern of an increase over the season.

Residual body condition did not differ with the age or sex of captured birds. (for American Redstarts, Cerulean Warbler, Tennessee Warbler, Northern Waterthrush, and Mourning Warbler (ANOVA, all $P > 0.06$).



Both MOWA and NOWA however, did not show significant changes in body condition. It is possible that these birds, which are typically forage in the understory or ground are not able to take advantage of the high arthropod abundances in the canopy often associated with Inga trees. The previous 3 species, though are canopy foragers and likely used Inga trees.

Resighting & survival estimation

Photos from Gabriel Colorado

Annual survival 2005-2008; Model-selection in MARK

Survival model (φ)	K	AICc	ΔAICc	ω_i
$\varphi_{age,}\ p$	3	59·94	0·00	0·32
$\varphi_{,}\ p$	2	61·00	1·06	0·19
$\varphi_{age,}\ p_{sex}$	4	62·34	2·40	0·10
$\varphi_{age + year,}\ p$	5	62·79	2·85	0·08
$\varphi_{year,}\ p$	3	62·85	2·91	0·07
$\varphi_{sex,}\ p$	3	63·07	3·13	0·07
$\varphi_{,}p_{sex}$	3	63·32	3·38	0·06
$\varphi_{age + sex,}\ p$	5	64·81	4·87	0·03
$\varphi_{year,}\ p_{sex}$	4	65·30	5·36	0·02

Not shown are models: φ year, *p* year; φ sex, *p* sex; φ age + year, *p* sex; φyear + sex, *p*; φ age + sex, *p* sex

Twenty-five of the 29 color-banded Cerulean Warblers were resighted within the banding season after the initial banding event.

In fact, some birds seemed to be defending territories and were resighted on a weekly basis throughout the season.

Using Program MARK, apparent monthly survivorship for Cerulean Warblers was estimated as 0.97 ± 0.020 SE.

There were no differences in survival based on the sex or the age of the bird.

Within Program MARK, we used the Barker model (Barker 1997) to estimate apparent survival rather than a traditional Cormack-Jolly-Seber survival model (Cormack 1964, Jolly 1965, Seber 1965) because the Barker model allows for live (e.g., recapture or resightings) and dead encounters to better estimate survival (Collins and Doherty 2006). Parameters in the Barker model included: apparent survival (φ), recapture probability (*P*), the probability of finding a bird dead (*r*), the probability a bird lives (*R*) or dies (*R*') and is resighted before the next capture period, the probability a bird staying in the area (e.g., fidelity) and remains at risk of capture in the next capture period (*F*), and the probability of fidelity to another area (*F*').

Within-season survival: breeding

0.98 ± 0·01SE monthly apparent survival

Based on a 6-year study in Ontario, Canada by Jones et al (2004).

Within program MARK (White & Burnham 1999), we used the Barker model (Barker 1997) to estimate apparent monthly survival rather than a traditional Cormack-Jolly-Seber survival model because the Barker model allows for live encounters (e.g., recapture or resightings) between capture periods to better estimate survival (Collins & Doherty 2006). Parameters in the Barker model included apparent survival (φ), recapture probability (*p*), the probability of finding a bird dead (*r*), the probability a bird lives (*R*) or dies (*R*') and is resighted before the next capture period, the probability a bird staying in the area (e.g., fidelity) and remains at risk of capture in the next capture period (*F*), and the probability of fidelity to another area (*F*'). Because no birds were recovered dead, *r* was set equal to 0. In addition, no birds were captured/resighted during migration or the breeding season, hence, both *R* and *R*' were set equal to 0 during this time interval. Fidelity parameters were set equal to one another and constant across time. Our small sample size (*n* = 29) restricted us to running relatively simple models. Apparent monthly survival and recapture probability were modeled as constant and as a function of season. Seasons included 1) winter (constant or different) or 2) between years, which included 2 migration events and the breeding period. Given that Cerulean Warblers exhibited two possible behaviors on the wintering grounds territory-holder or flock member (M. Bakermans, personal observation), we used the term 'territorial' as a covariate. We defined winter territory-holders as birds captured/resighted 2 or more times within the same season with at least 7 days between the events (*n* = 20; Chase et al. 1997). All other remaining birds were classified as flock members (n = 8) unless they were seen on greater than 2 occasions in the second season (*n* =1). Although many flocking birds were resighted within and between seasons, suggesting that they remained in the general study area, we expected that recapture probability would be lower for flock members. We also used age and sex of the bird as covariates in the analyses. Model selection was based on Akaike's

Survival during Migration

- $\varphi_{annual} = \varphi_{breeding} \times \varphi_{migration} \times \varphi_{wintering}$
- Using Bootstrap resampling methods, we generated a standard error of apparent migration survival based on random combinations from 20 simulated samples of each value for the annual cycle.

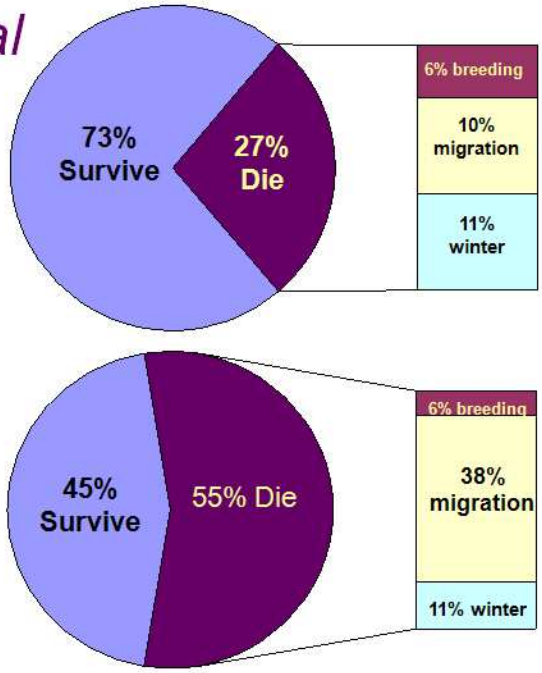
Survival during migration

- Overall monthly migration φ = 0.93 (0·07 SE)
  - Adults φ : 0·97 (0·06 SE) monthly
    - 0.86 over 5-month migration period
  - Juveniles φ : 0·88 (0·07 SE)
    - 0.53 over 5-month migration period

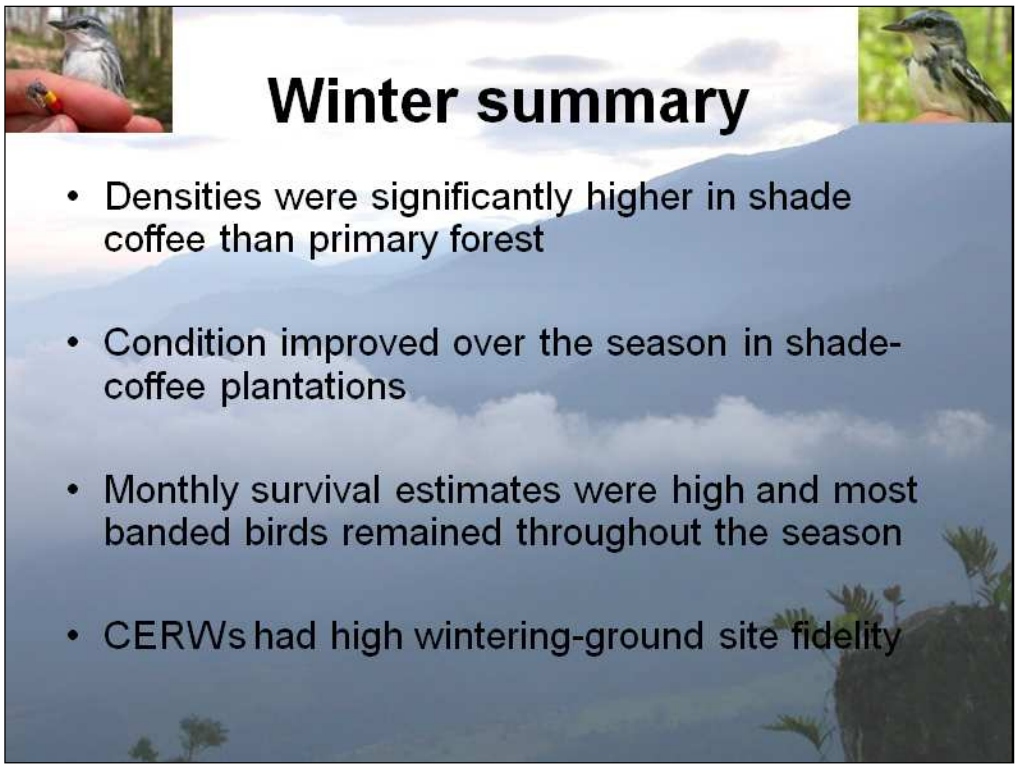
Annual survival

Adults

Juveniles



Annual survival based on winter captures & resights



I'd like to summarize my findings on the wintering grounds now.

Although researchers have suggested that shade coffee plantations serve as high quality habitat for a variety of Neotropical migrants our study is the first to compare densities of migrants in shade coffee and primary forests using distance-based methods.

Our study, while accounting for detectability supports previous results of higher numbers of migrant birds in shade coffee plantations.

Next, we found high monthly survival estimates were comparable to rates for other wintering Neotropical migrants.

Also, this rate is similar to the monthly survival rate (of 0.98) calculated on the breeding grounds in Ontario by Jones et al. (2004).

Keep in mind, though, that mortality may be higher on these stationary periods (i.e., breeding and nonbreeding) for birds forced into marginal habitats.

CERWs had high between season fidelity and few studies have found return rates as high for other species.

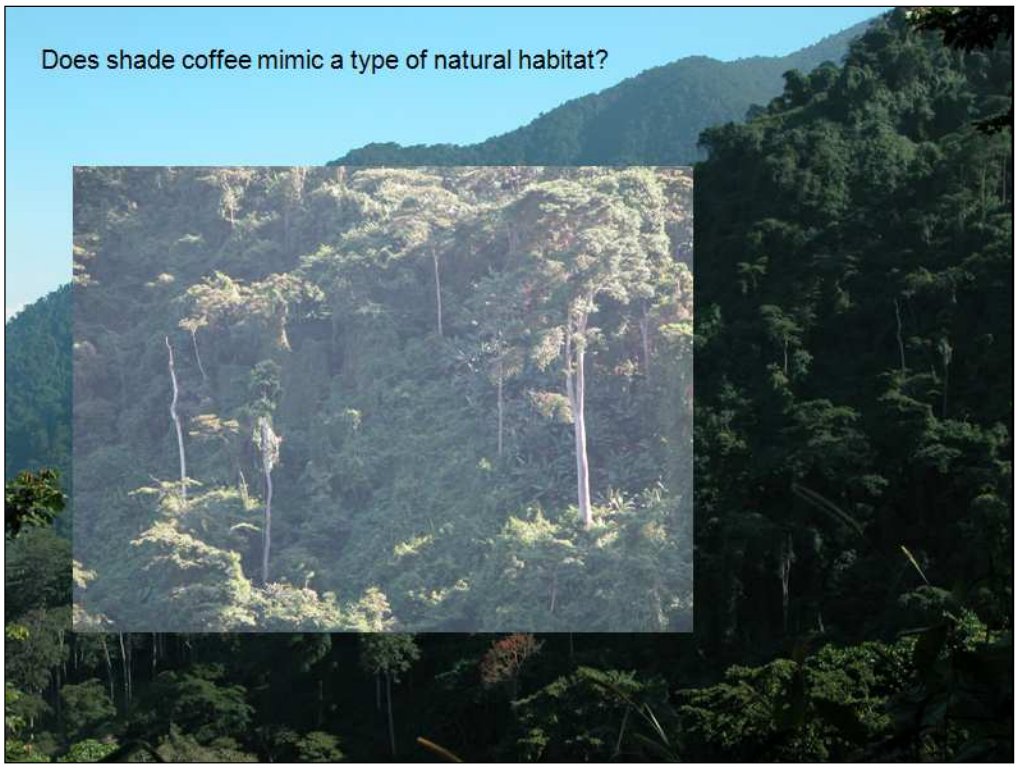
At the same time, such high values of annual return could place Cerulean Warblers in jeopardy because wintering ground habitat in the Andes is rapidly being converted to sun coffee and/or open pasture

Key Demographic Findings

- Ceruleans had high overwinter survival and showed high site fidelity in shade-coffee plantations.
- Adults have far greater survival than juveniles.
- Mortality is greatest for juveniles during migratory periods.
- Our estimate of adult survival would change some populations to "sources" (i.e. Ontario and Tennessee) with $\lambda > 1$, whereas other sites (e.g., Indiana and Mississippi Alluvial Valley) still would be considered sink populations (i.e. $\lambda < 1$).


Conversion to pasture
is growing threat.


CERULEAN WARBLER
CONSERVATION COFFEE
Audubon
FRENCH ROAST
FAIR TRADE
CERTIFIED
sustainability: COFFEE
BIRD FRIENDLY
Smithsonian Migratory Bird Center
Artist: Roger Puente


Does shade coffee mimic a type of natural habitat?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MeadWestvaco
Wayne National Forest
Ohio Div. of Forestry
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ODNR, Division of Wildlife
USFWS, NMBCA
National Fish and Wildlife Foundation
National Council for Air and Stream Improvement
OSU, School of Environment & Natural Resources
OSU, Terrestrial Wildlife Ecology Lab
The Nature Conservancy
Cleveland MetroParks Zoo
Ohio Ornithological Society
OSU, Center for Latin American Studies
OSU, Office of International Affairs
AOU Student Travel Award
OSU, Council of Graduate Students


OLINDA I
OLINDA II

Sample size (n), detection probabilities (P_a), and distance-based density estimates (D) generated in Program Distance for the 4 most common species in the Venezuelan Andes, 2005-2007.

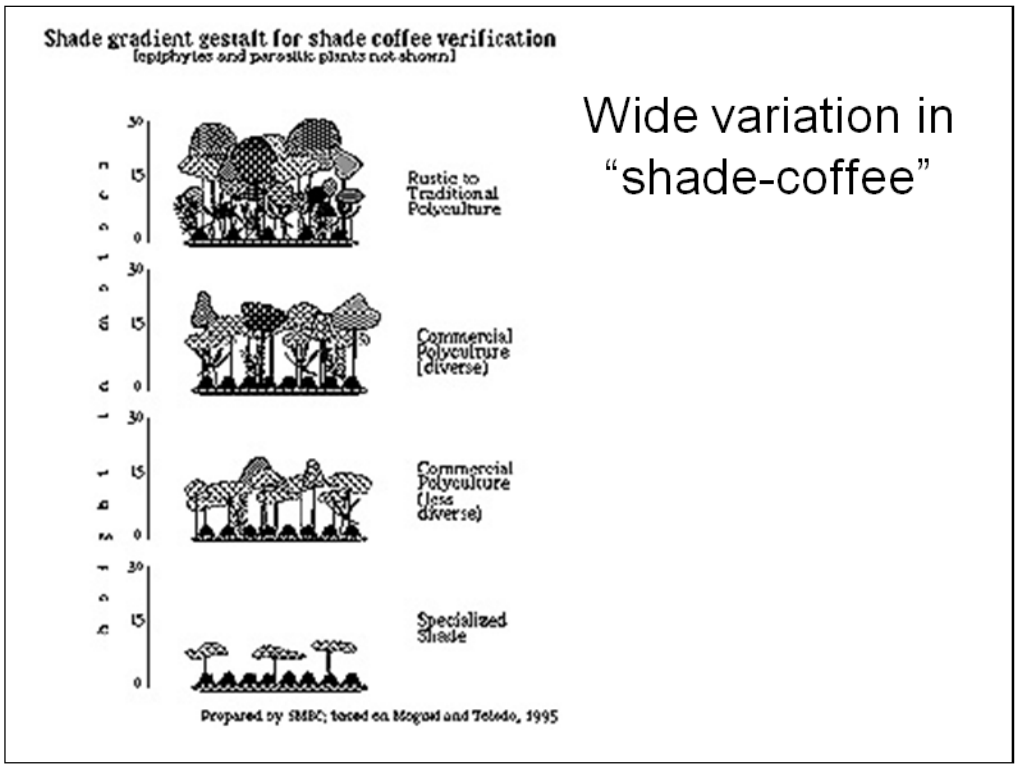
	Shade coffee plantation			Primary forest		
Species	n	P_a	D (SE)	n	P_a	D (SE)
American Redstart	99	0.58	3.39 (0.67)	32	0.57	0.91 (0.23)
Blackburnian Warbler	46	0.74	1.12 (0.27)	15	0.57	0.42 (0.15)
Cerulean Warbler	63	0.59	2.51 (0.63)	6	0.57	0.17 (0.09)
Tennessee Warbler	48	0.67	1.26 (0.45)	13	0.57	0.37 (0.14)

Tree species use

Substrate species / Spp code	Proportion Expected	Proportion Observed	Bonferroni confidence interval[a]
Inga spp. / Ing sp	0.43	0.55	$0.474 \leq P_1 \geq 0.626$*
Unknown	0.09	0.18	$0.121 \leq P_2 \geq 0.239$*
Acnistus arborescens / Acn arb	0.17	0.12	$0.070 \leq P_3 \geq 0.170$
Cedrela mexicana / Ced mex	0.11	0.09	$0.046 \leq P_4 \geq 0.133$
Persea americana / Per ame	0.08	0.04	$0.010 \leq P_6 \geq 0.070$**
Erythrina glauca / Ery gla	0.09	0.18	$0.090 \leq P_9 \geq 0.010$**

a P*i* represents theoretical proportions of occurrence and is compared to proportion of expected use. If the expected proportion is outside the confidence intervals of observed use than the hypothesis of proportional use is rejected. * = used more and ** = used less than expected by chance (significant at the 0.05 level).

Tree and shrub species identified in shade coffee plantations and the proportion of each substrate observed in foraging attempts and expected throughout the plantation. Simultaneous Bonferroni intervals were calculated using methods described in Byers et al. (1984). Species with expected frequencies <5 were excluded from analyses, including *Ficus* spp., *Citrus* spp., *Coffea arabica* (Cof ara), *Piper aduncum*, *Cecropia* spp., *Heliocarpus americanus* (Hel ame), *Ceiba pentandra*, *Acacia* spp., *Annona muricata*, *Theobroma cacao*.



Wide variation in "shade-coffee"

So as my take home message that I want you to remember today, is that based on our examination of several parameters (density, body condition, overwinter persistence, and annual return), I suggest that shade coffee plantations in the Venezuelan Andes provide high quality wintering habitat for Cerulean Warblers and other migratory species.